AI Planning
Exercise Sheet 8

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Students: Axel Perschmann, Tarek Saier

Exercise 8.1

General idea: heuristic values are completely dependent on the chosen projection π_P.
Example:
The heuristic value for the abstraction induced by $\pi_{\{\text{truck A, truck B}\}}$ of I is 0:
$h^{\{\text{truck A, truck B}\}}(LRR) = 0$, as opposed to:
$h^{\{\text{package, truck A}\}}(LRR) = 2$
$h^{\{\text{package, truck B}\}}(LRR) = 2$

The above illustrates that it is important to choose the pattern wisely. Prune variables that are less significant, keep those that are most relevant for the goal formula.

Exercise 8.2

Definitions/Notes:

- (1) $\Pi = \langle V, I, O, \gamma \rangle$ (in FDR) is SAS$^+$ iff
  - $\forall o \in O$ have no conditional effects
  - $\forall \chi$ of $o \in O$ and γ are conjunctions of atoms
- (2) $\mathscr{T}(\Pi) = \langle S, L, T, s_0, S_\star \rangle$ is the induced transition system of $\Pi = \langle V, I, O, \gamma \rangle$ where
  - S is the set of states over V
  - $L = O$
  - $T = \{\langle s, o, t \rangle \in S \times L \times S | app_o(s) = t\}$
  - $s_0 = I$
  - $S_\star = \{s \in S | s \models \gamma\}$
- (3) For $\mathscr{T} = \langle S, L, T, s_0, S_\star \rangle$ and $\alpha : S \to S'$ (a surjective function), $\mathscr{T}^\alpha = \langle S', L, T', s'_0, S'_\star \rangle$ is the abstraction of $\mathscr{T}$ induced by α where
  - $S' = \{\alpha(s) | s \in S\}$
  - $T = \{\langle \alpha(s), \ell, \alpha(t) \rangle | \langle s, \ell, t \rangle \in T\}$
  - $s'_0 = \alpha(s_0)$
  - $S'_\star = \{\alpha(s) | s \in S_\star\}$
- (4) $P \subseteq V$ is a pattern, $\Pi|_P$ denotes Π restricted to the variables in P

- (5) π_P is the projection $S \to S'$ for P, $\pi_P(s) := s|_P$, $\mathscr{T}^{\pi_P}$ denotes the transition system induced by π_P
- (6) two transition systems $\mathscr{T}$ and $\mathscr{T}'$ are graph-equivalent ($\mathscr{T} \overset{G}{\sim} \mathscr{T}'$) if there exists a bijective function $\phi : S \to S'$ such that
  - $\phi(s_0) = s'_0$
  - $s \in S_\star$ iff $\phi(s) \in S'_\star$
  - $\langle s, \ell, t\rangle \in T$ for *some* $\ell \in L$ iff $\langle \phi(s), \ell', \phi(t)\rangle \in T'$ for *some* $\ell' \in L'$

(a) to show: $\mathscr{T}(\Pi|_P) \overset{G}{\sim} \mathscr{T}(\Pi)^{\pi_P}$ if Π
- is an SAS$^+$ planning task
- is not trivially unsolvable
- has no trivially inapplicable operators

In terms of the definitions/notes above: (6) holds between:
- (4), then (2)

and
- (2), then (5) — the latter being a special case of (3)

$\mathscr{T}(\Pi|_P)$:
The difference to $\mathscr{T}(\Pi)$ in this case is V of $\Pi|_P$, which affects S directly and T and $S_\star$ indirectly. S will not include states over $V \setminus P$. T and $S_\star$ will be restricted accordingly.

$\mathscr{T}(\Pi)^{\pi_P}$:
The difference to $\mathscr{T}(\Pi)$ in this case is that after getting $\mathscr{T}$ the latter is abstracted by means of π_P. This means for all states $s' \in S'$ of $\mathscr{T}^{\pi_P}$, $s \in S$ of $\mathscr{T}$: $s' = s|_P$. In other words, information about variables $v \notin P$ will be discarded in all s'. Again, T and $S_\star$ will be restricted accordingly.

In both cases all information about variables not in P is discarded. Performing this step by means of (4) before (2) or by means of (5) after (2) does not violate (6).

(b) Replacing effect conditions in $o \in O$ with $\top$ causes problems with the third (see (6) above) condition of graph-equivalence that deals with transitions.